Field emissions of N2O during biomass production may affect the sustainability of agro-biofuels

Carter, Mette Sustmann; Hauggaard-Nielsen, Henrik; Heiske, Stefan; Thomsen, Sune Tjalfe; Jensen, Morten; Schmidt, Jens Ejbye; Johansen, Anders; Ambus, Per

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

Field emissions of N_2O during biomass production may affect the sustainability of agro-biofuels

Mette S. Carter[1], Henrik Hauggaard-Nielsen[1], Stefan Heiske[1], Sune T. Thomsen[1], Morten Jensen[1], Jens Ejbye Schmidt[1], Anders Johansen[2] and Per Ambus[1]

[1] Biosystems Division, Risø National Laboratory for Sustainable Energy, Technical University of Denmark, P.O. box 49, 4000 Roskilde, Denmark

[2] Department of Environmental Chemistry and Microbiology, National Environmental Research Institute, University of Aarhus, P.O. box 358, 4000 Roskilde, Denmark

Corresponding author: Mette S. Carter, tel. +45 2133 1383, e-mail: mthy@risoe.dtu.dk

Abstract

One way of reducing the emissions of fossil fuel-derived carbon dioxide (CO_2) is to replace fossil fuels with biofuels produced from agricultural biomasses or residuals. However, cultivation of soils results in emission of other greenhouse gasses (GHGs), especially nitrous oxide (N_2O). Previous studies on biofuel production systems showed that emissions of N_2O may counterbalance a substantial part of the global warming reduction, which is achieved by fossil fuel displacement. In the present study, we related measured field emissions of N_2O to the reduction in fossil fuel-derived CO_2, which was obtained when agricultural biomasses were used for biofuel production (Carter et al., in press). The analysis included five organically managed feedstocks (*viz.* dried straw of sole cropped rye, sole cropped vetch and intercropped rye-vetch, as well as fresh grass-clover and whole crop maize) and three scenarios for conversion of biomass into biofuel. The scenarios were i) bioethanol only, ii) biogas only and iii) co-production of bioethanol and biogas. In the last scenario, the biomass was first used for bioethanol fermentation and subsequently the effluent from this process was utilized for biogas production. The net GHG reduction was calculated as the avoided fossil fuel-derived CO_2, where the N_2O emission was subtracted. This value did not account for fossil fuel-derived CO_2 emissions from farm machinery and during conversion processes that turn biomass into biofuel. The greatest net GHG reduction, corresponding to 700-800 g CO_2 m^{-2}, was obtained by biogas production or co-production of bioethanol and biogas on either fresh grass-clover or whole crop maize. In contrast, biofuel production based on lignocellulosic crop residues (*i.e.* rye and vetch straw) provided considerably lower net GHG reductions (≤ 215 g CO_2 m^{-2}), and even negative numbers sometimes. No GHG benefit was achieved by fertilizing the maize crop because the extra crop yield, and thereby increased biofuel production, was offset by enhanced N_2O emissions.

Keywords

bioethanol and/or biogas, carbon sequestration, digestate recycled as fertilizer, emission factor, fossil fuel displacement, grass-clover, methane, nitrous oxide, rye and vetch straw, whole crop maize

Acknowledgements

This work was part of the BioConcens project (Biomass and bioenergy production in organic agriculture – consequences for soil fertility, environment, spread of animal parasites and socio-economy) funded by the International Centre for Research in Organic Food Systems (ICROFS). The first author would like to

thank the HighCrop project (Higher productivity in Danish arable crop production) for economic support, which enabled participation in NCGG-6.

References

Carter, M.S., Hauggaard-Nielsen, H., Heiske, S., Jensen, M., Thomsen, S.T., Schmidt, J.E., Johansen, A. and Ambus, P. (in press) Consequences of field N_2O emissions for the environmental sustainability of plant-based biofuels produced within an organic farming system. Global Change Biology: Bioenergy.